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On the Classification of WATER BIRDS.*

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By "water birds" is meant the swimmers proper, as distinguished from aquatic, or even natatorial, *Grallæ*. That the *Natatores*, so accepted, are one of three primary divisions of birds, at least of carinate birds, is held to be demonstrable. I shall attempt the proof, and endeavor to define the natural orders and families of the sub-class. I am authorized to state that the classification here proposed has been adopted without modification by the Smithsonian Institution, in the arrangement of the *Natatores* in its museum.

Not to allude to early classificatory schemes that the progress of ornithology has shown to be impossible, nor to those late systems, based upon the inestimable labors of Müller, Burmeister, Sundevall, Cabanis and others, that relate mainly to the arrangement of the higher groups, there still remain several that must be taken into the present consideration. Notably, those of Nitzsch, Vigors, Bonaparte, Lilljeborg and Huxley, which bear directly upon the subject in hand; notice of which is necessary before defining the modification of one of them that it is the design of the present paper to establish.

It may be here premised, and safely asserted, that heretofore no two ornithologists, bringing original research, and the conclusions deduced from it, into action, have been able to agree closely in classification. There are as many systems as there have been leaders in the science. But conflict in the field of taxonomy has been chiefly along the line of the higher groups,—more particularly *Passeres*. Respecting the Natatores, a singular unanimity has prevailed in the definition of the group; and in the main, similar subdivisions have been recognized, however differently these have been collocated, and estimated in the scale. Intermediate or "doubtful" forms are limited to two or three families. Only one author stands far apart from the rest in the distribution of natatorial families, assigning part of them among what are known as "Grallæ," and the others with certain insessorial types. These facts have perhaps another significance than that of simple matters of ornithological record.

Referring to the authors just mentioned, we find four principal methods of primary division of birds: (1) a dichotomous arrangement in two "parallel series," based upon one physiological character,—*Bonaparte;* (2) a trichotomous, founded upon very general considerations,—*Nitzsch*, and after him *Lilljeborg;* (3) a quinary, a modification of the second, by dividing two of the three divisions into two each, and with minor changes,—*Vigors*, and many others; (4) another trichotomous, but from a totally different standpoint—recognition of birds as modified reptiles—and carried out with special reference to one anatomical character, afforded by certain cranial bones,—*Huxley*.

After Oken's generalizations upon the condition of newly-hatched birds, Bonaparte made the scheme of *Altrices* and *Præcoces* his own by strenuous, unqualified advocacy, and elaboration of details with surprising care and skill. The system took strong root, and is held by many as the key-note of the natural classification, comparable, in equivalency, to such profound divisions as e. g., *Exogens* and *Endogens* among flowering plants, or *Placentalia* and *Monotremata* among mammals. That the system has been unduly stretched may perhaps be shown.

Comparison, for instance, of Bonaparte's two subclasses with those of placental and implacental mammals, may show how far the former may be carried. There is, I believe, a perfect parallelism in the physiological point involved between mammals and birds; but it does not reach to the grade just supposed. In Marsupials, the condition of the young at birth is associated with a radical modification of the generative apparatus in both sexes. The sexual organs alone would enable us to predicate, regarding the condition of the fœtus at term, a departure from the ordinary standard obtaining in higher orders, even were we unable to say in what the difference would consist. It is not so with birds; if there be any structural modifications correspondent to altricial and præcocial nature, they remain to be discovered. From nothing now known could either be predicated, in any given instance; our inferences would be purely upon consideration of known allied forms.

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*Considerable time has passed between the preparation and the publication of this paper; in revising the proofs I have added foot-notes, where comment or explanation seemed desirable, in preference to altering the original text; this is left untouched.

Marsupials are so far "synthetic" that they comprehend the semblances of other mammalian orders. There are carnivorous, herbivorous, quadrumanous, etc., marsupials. The number of forms that a given group may represent or repeat under modifications peculiar to itself, is a well-known test of the character of such assemblage, and in a measure of its grade in a taxonomy, only inferior to that afforded by the modifications themselves. Marsupials and Monotremes conform in both ways to the requirements of a primary division of mammals. But among birds, altricial and præcocial orders must be so drawn that, while they are mutually representative to a degree, as wholes, they do not include, each in itself, modified representations of each other. Thus, *e. g.*, in Bonaparte's parallel of altricial *Gaviæ* and præcocial *Anseres*, among swimmers, it is impossible to find families representing each other to anything like the degree, or in anything like the number of cases, that may be shown when *Natatores* are divided upon another basis, and the families differently worked out.

If helplessness at birth, compared with precocity, means, among birds, "high" as opposed to "low" in the scale, then either the reverse is the case with mammals, or else we must compare altricial *Insessores* with marsupials, and præcocial *Natatores* with the higher orders: a dilemma, either horn of which is sufficiently difficult.

I believe that the strongest analogy, if not actual homology and exact parallelism, between the altricial and præcocial series of birds, and certain conditions of mammals, really does exist. My meaning will be evident, if I simply refer to the difference between a kitten or puppy at birth, and a newly-born calf or colt. If all mammals are "altrices" by their very nature, as expressed in their name, there is a distinction with a difference in the two modes of exhibiting this nature. The young of one series of mammals are born weak and helpless, unable to stand, often blind and naked; the nipple must be brought to these. In the other series, the young walk or swim at birth, are clothed like the parents, and can see; these betake themselves to the nipple. Here is the mammalian representation of the two avian series. This is so evident and so certain that it must have been already recognized, though it is original so far as the writer is concerned.* As among birds, moreover, this distinction marks, in a general way, large groups; even orders might be based upon it. But it would not suffice for a primary dichotomous division of mammalia, even of placental mammals; nor, should occasion arise, as when its requirements did not accord with structural modifications, would it take precedence over the latter, to the dismemberment or inversion of natural groups.

In opposing undue estimate of the value of this physiological character, I am far from underrating, still less ignoring, its import. As collateral testimony in the formation of orders and location of families, it has much weight; and

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*I find exact expression of the case:—"The differences in degree of individual development attained at birth parallel, in Mammals, those in Birds expressed by the terms *altrices* and *præcoces*. The hoofed quadruped enters the world with the use of all its senses; in a few hours can follow the dam, and keep pace with her if she sees cause for flight: the feline is born blind and helpless; some days elapse ere the commissure of the eyes is unsealed."—OWEN, on *membrana pupillaris*, Comp. Anat. and Phys. Vert. iii, p. 754, 1868.

certain doubtful cases will probably be decided by reference to it. It draws a sharp, if here and there a broken, line between *Gallinæ* and *Columbæ*. It separates, with precision, Herons and their allies from other *Grallæ*. It goes some way in distinguishing lamellirostral from other Natatores ; and other instances of its application might be cited.

Some other points are to be considered in this connection. The various conditions of single, double, and middle monogamy, and polygamy, are to be regarded. Some generalizations, apparently important, may be drawn from the comparative size of the air-space in the eggs of the two series.* *Altrices* usually lay few eggs, *Præcoces* many; an evident adaptation to facilities of caring for young under the two régimes. Yet an immense group of præcoces — *Grallæ*—lay but four, which is below the average of altricial Insessores. There are also many families among *Rasores* and higher *Grallæ*,—too many to be considered as exceptions proving a rule,—in which altricial or præcocial characters are but doubtfully expressed, or else do not agree with unquestionable affinities in other respects. Finally, it should be observed that, as all Insessores are altrices, no parallelism exists between the great majority of existing birds and the præcocial series of walkers, waders and swimmers, the relationships between which and Insessores, if any, are only of remote analogy, not affinity. To speak figuratively: we come a long way,—the greater part of the whole way—down the bird scale, before meeting with any indications of difference in this physiological point. Arrived at the lower walkers, and higher waders, we first dimly see a certain principle striving, with uncertain results, to assert itself. Wavering for a while, at length it gains force and effects fissuration of birds into two or more "parallel"—*i. e.*, self-repeating or self-representing—series; the main stem continues unaltered, through wading Herons to swimming *Totipalmi*, *Longipennes*, &c. ; the fork, first distinct among some walkers, thence continuing through the smaller *Grallæ*, &c., to anatiform swimmers. This is a matter of observation, not an hypothesis; is it sufficient basis for a primary division of birds ?

In the application of Bonaparte's principle to our subject of swimming birds, the results are seen to be no better than was to have been expected. It is difficult to say which one of this author's many schedules, variously modified, should be held most expressive of his views. That given in the Comptes Rendus of Oct. 31, 1853, probably does his classification the most justice. Here water birds form his sixth order, *Gaviæ*, comprehending *Totipalmi* and *Longipennes*, and his tenth, *Anseres*, including all other Natatores. The two groups are separated by all the *Rasores*, the Struthious birds, and all the *Grallæ* except Herons. Beyond question, swimming birds, however viewed as to their subdivisions, cannot be separated thus; the steganopodous and macropterous Natatores cannot be separated from others by three, or by any, orders. Here they are made to differ more from other swimmers than the Gallinaceous and Grallatorial birds do. The structural differences between a penguin and a duck are certainly as great as those between an auk and a cormorant ; yet in one instance the birds stand side by side in the system, in the other they are divided by intervention of three diverse orders. But a more serious objection to this schedule, and one, too, coming from the author's own side of the question, is found in the fact that *Urinatores* are not all *Præcoces*, as they were in this place represented. They were consequently subsequently referred to *Gaviæ*, and the penguins made a distinct order. But it so happens, unfortunately or otherwise, that neither are the *Urinatores*, with or without the penguins, all *Altrices*. In short, birds will not lie conformably disposed in the two Procrustean beds of *Altrices* and *Præcoces*. As far as known, all *Insessores* (qu. *Columbæ ?*), *Herodiones*, *Steganopodes*, and *Longipennes* are Altrices ; *Struthiones* and *Lamellirostres* are Præcoces; beyond these, neither can be safely predicated of groups of higher rank than families, without exceptions and reservations.

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* Cf., e. g., G. A. Lewis' Lectures on Ornithology, pt. i, p. 17.

As the sum of the criticism I would be disposed to offer on Bonaparte's arrangement, I would say: Not to refer to *Rasores*, *Grallæ* and *Natatores* as varying exponents of two primes, altrices and præcoces, but to regard the former as themselves the integers, of which "altricial" or "precocial" are predicable as exponents of modifications of which the three are alike susceptible. So, therefore, altricial or præcocial *Natatores*, not natatorial *Altrices* or *Præcoces*.*

Nitzsch's earlier classification† was a dichotomous division of *Aves* into *Carriatæ* and *Ratitæ*, after Merrem; an arrangement that anticipated the later one of Prof. Huxley in separating the struthious birds from those with a keeled sternum. He afterwards‡ became satisfied that *Struthionidæ* et aff. should come among Cursores, and divided all birds into *Av. Aëreæ*, *Av. Terrestres*, and *Av. Aquaticæ*,—birds of the air, earth and water. These are difficult of precise definition in terms descriptive of structural modifications, in consequence of the occurrence of intermediate and aberrant forms, that furnish exceptions to almost any possible diagnosis. But it comprehends a broad, well-founded generalization, violates the requirements of no natural groups, and largely fulfils the main conditions of a natural system. If the point be well taken, it follows that birds—that Carinate birds at any rate—are modelled after three types, that, however modified or even changed into the semblance of each other in some cases, retain definite tangible characters. The system appears susceptible of a crucial test. If it be true, each one of the three main stems of the bird type must repeat or represent, with unquestioned fidelity, in some one or more of its branches, the other two. Among the orders and families into which, *e. g.*, Natatores are differentiated and specialized, representations of Aëreæ and Terrestres must be found; the relationships, of course, not of actual affinity, but of analogical resemblance. I think that the system will stand such test, and shall in the sequel apply it in some detail. Establishment of one of the three groups is tantamount to fixing the other two.

Nitzsch's Natatores are a suborder *Av. aquat. palmatæ*, as distinguished from *Av. aq. grallæ*. He adopts five "families," two of which are rather associations of families (*Steganopodes* and *Pygopodes*). He places the Flamingoes (called *Odontoglossæ*) in Grallæ. *Podoa* he adds to *Steganopodes*.

The quinary system of Vigors,‖ in its primary divisions, is a modification of the trichotomous just noticed. Disregarding subclasses, he proceeds at once to five orders. The two first are a division of *Av. Aëreæ* into *Raptores* and *Insessores*, according as the birds are habitués of the upper air or of the trees more particularly,—a distinction better borne out by actual structure of the birds than by reference to this assumed difference. Nitzsch's two divisions of *Av. aq. Grallæ* and *Palmatæ* give, with scarcely a variation, Vigors' two last orders *Grallatores* and *Natatores*. Vigors' middle order, *Rasores*, comprehends gallinaceous birds and pigeons. That these divisions are in the main strictly natural, is probably not open to serious question. A chief defect is in the inequivalency of the five orders. Thus *Rasores* contains types more dissimilar from each other than *Raptores* are from (other) *Insessores*; and this, too, without taking *Ratitæ* into consideration. If he would make ordinal distinction of *Raptores* and *Insessores*, *pari passu* he should have separated *Columbæ* from *Gallinæ*. His *Insessores*, again, contain types as mutually dissimilar as either of them are from *Raptores*. Without opening here the question of *Ratitæ*, nor of recognizing, aside from ostriches, groups higher than orders, it may be said that this system requires modification in the adoption of several more orders,—his *Rasores* and *Insessores* especially demanding dismemberment into two or three.

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* In this discussion of Bonaparte's scheme, it might be objected that I galvanize a dead body in order to kill it over again. But doubtless my objectors can call to mind several signal instances where, within the last few years, Bonaparte's system has been accorded the importance which is here criticised.

† Observ. de Av. Art. Carot. Comm. 1829.

‡ Pterylographie, etc., 1840.

‖ Obs. on the Nat. Affin. that connect Ord. and Fam. of Birds. Trans. Linn. Soc. xix, 1827.

By this means we should arrive at about a dozen orders of apparently the same taxonomic value.

With endless minor modifications at different hands, yet with main points intact, this system has come into general use, holding its own against many technical objections, with a vitality something remarkable in the history of the science. There is that about it that appeals strongly to general opinion, representing average "common sense," and commands assent, however qualified and guarded. The most extensively used, it is also the best abused system of all, particularly in that phase it gained at the hands of Swainson et aff. Much argument, and not a little invective, has been wasted, or worse, upon the various "quinary," "septenary," "circular," &c., systems that have revolved like satellites around Vigors' standpoint. It must be vital, or it would before this have been buried. It must be weak at points, or it could not have been so successfully attacked. It appears to have suffered more from the indiscretion of its friends than the hostility of its enemies.

The child's "classification" is the placing of objects in a line one after the other. A step in advance is their arrangement in several contiguous lines, straight or waved, parallel, oblique or crossing. The insurmountable difficulty is that these lines lead anywhere,—nowhere in particular. Any linear arrangement is so clearly impossible, that I only excuse myself for alluding to it at all by taking it as the initial point of departure in this portion of the present essay. It was a stride onward when the idea was conceived of making these lines return upon themselves. Not only were otherwise inevitably bizarre juxtapositions done away with, but a greater end, the production of surfaces instead of lines, was secured. Anywhere in these planes, from centre or type-point to periphery or aberrant points, forms could be located. With the "circle," an indefinite number of points of contact or inosculation became possible. The circularian could bring his three, five, seven, or other "subtypical" forms around his "type circle," weigh the importance of each by the size of his circles, and grade relationships from near affinity to remote analogy. The elastic system seemed perfect with its machinery of "wheels within wheels." Criticism of this scheme has too often ended in a smile or a sneer, yet without touching upon the really vulnerable point. A system that disposes objects in circumscribed planes is a great advance over a linear arrangement, but it stops half-way to the goal. The third dimension is needed; to length and breadth must be added thickness; the circle must become a sphere.

Thus I conceive that every group of birds, from the assemblage of individuals called a species, to the very highest, constitutes or represents a solid of the three dimensions. We cannot predicate affinity or analogy only to the right or left,—the top or bottom,—but must take it that all groups, near or remote, may approach, touch, or fuse with each other, along the axis of either of the three possible diameters. With whatever result in our attempt to project an ornithological system on flat paper, yet we cannot imagine the groups to be all distributed in one plane surface, or even in several "higher" or "lower" parallel planes. Just as the stars, that appear scattered on a concave surface, are harmoniously distributed throughout space in its three extensions, so, types of birds with reference to each other. The avenues of mutual approach, whatever their number, do not all lie in one plane, but may lie in any of the perpendicular planes whose intersection generates a solid.

I used the word "sphere" merely as the general expression of solids with indefinite number of sides; not presuming to say that this is the real shape either of birds as a unit, or of their subdivisions. Birds could only assume this shape if developed equally in all directions, which apparently, I may say certainly, is not the case. The figure may be conoidal, like half an hour-glass, whose other half is reptiles, or only the Pterosaurian type of that class; the two meeting at a point, perhaps *Archæopteryx*. Speculations upon the contour of the figure are, however, out of place. Again, the superficies of this solid, whatever its form, is not necessarily, nor even probably, smooth. We may conceive of it as presenting irregular saliencies drawn out even into arm-like processes, reaching toward, or touching, mammalian, reptilian and piscine groups; or reëntrances, into which are extended corresponding outgrowths from other forms of life. Classification is not the laying side by side of plane figures, circular or otherwise; but the piling over against each other of variously shaped solids, that meet and fit at mutually conformed and adapted points or surfaces of contact. The bird is laid against the mammal at the point *Struthio*; against the reptile at the point *Archæopteryx*, or rather by a surface of which this type was one point; against the fish (probably the Elasmobranchiate fish) at the point *Spheniscus*, and so on. Inside the figure Aves, everywhere from centre to superficies, lie piled in certain order, all lesser figures, from species to sub-class, mutually fitting on every side. The problem is to discover, as nearly as may be, the plan according to which the several stones are shapen, coäptated in the building of the solid structure. We do not deal with an empty shell.*

Professor Huxley's classification† is materially different from any other. It is probably the most stirring ornitholgical event since the discovery of *Archœopteryx.* It is an attempt to classify birds with reference to a single set of characters—the modifications of certain cranial bones. The test is critically applied and rigidly carried out, necessitating a new division of the class, by breaking up most of the higher groups usually recognized, substituting others, and calling for a hitherto unsuspected sequence of orders and families. The primary division is into three "orders," apparently correspondent in taxonomic value with the "sub-classes" of most writers. *Saururæ*, represented by the *Archæopteryx* alone; *Ratitæ*, including *Struthiones* et aff., seemingly about equivalent to *Platysternæ* Nitz., *Brevipennes* Lillj., *Cursores* s. *Currentes* alior.; and *Carinatæ*, embracing all other existing birds, that agree in the possession of a keeled sternum. This initial step, however, is taken upon other grounds than the characters of the palatal, &c., bones alone; and its adoption may be found imperative. I am not prepared to offer anything upon the question, *Carinatæ* only falling within the scope of the present paper. These are divided into four orders, correspondently with as many main modifications of the bony palate, that only exceptionally merge into each other. *Dicholophus*, *Crax* (*globicera*) and *Picidæ* are the only intermediate forms known to the author. The two first may be regarded "as transitional between the Schizognathous and Desmognathous sections, or, at any rate, as approaching the latter division" (l. c., p. 455). The woodpeckers "are in fact not Desmognathous, the palate in these birds exhibiting rather a degradation and simplification of the Aegithognathous structure," (p. 468.) The fact then is unquestionable, that *Carinatæ* may be divided into four groups by certain characters, the value of which, as affording correct indications of natural affinities or not, is the point at issue.

It will scarcely be questioned by any, that groups, to be taxonomically equivalent, should be separated from each other by characters of equal or corresponding value; that is, the sum total or average of distinctive features should be as nearly as possible of the same amount or degree. An inequality in this respect of the groups formed under this system is evident. Not to refer to the primary divisions, in the next lower scale, that of "sub-orders," one family stands apart from all other *Carinatæ*—the Tinamous alone representing *Dromæognathæ*. As the author truly says, "the small actual extent of the group in which" the dromæognathous structure obtains, is no argument against its validity as a sub-order. While this would be conceded, issue would be taken upon the question whether any other characters separate the Tinamous as widely from the *Rasores* with which they were associated, as the latter are separated from the birds of other orders; or, in a wider sense, are the Tinamous as different from all other *Carinatæ* as any Schizognathous bird, e. g. a plover, gull or dove, is from any desmognathous bird, as a hawk, parrot or cuckoo? If not, an inequivalency of value between the sub-orders is implied, without any reference of course to their comparative extent. Aside from the fact that the Tinamous have "a completely struthious palate," it would probably be denied by none—not even by the author himself—that no characters can be found whereby to separate *Tinamus* from other *Gallinæ* as a group of higher rank than a family; and further, that its peculiarities are of that kind or grade usually held throughout the ornithological system to be of family consequence.* But if *Tinamus* can sustain an order *Dromæognathæ*, the rest must follow. It is a fair test, apparently, of the real value of the basis of the system. Seeing that here the characters of the palate bones are at variance with all others, it is next to be inquired how far they agree with the indications of natural affinity, afforded in other instances by general characters.

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*The three foregoing paragraphs are allowed to stand as they were written, with some misgivings; not lest the thoughts that prompted them be not well enough, but lest the expressions used may fail to convey to others exactly the idea desired to be advanced. I do not expect to be here accused of using the imaginative in place of the reasoning faculties, unless I am misunderstood.

†P. Z. S., 1867, p. 415.

The schizognathous structure obtains† in all *Rasores* (excl. *Tinamus*) in *Columbæ*, in most *Grallæ*, and about half of *Natatores*. The desmognathous prevails in other *Natatores*, in *Herodiones* of *Grallæ*, in all *Raptores*, and part of higher *Insessores*, (not necessary to particularize here,) the rest of the latter being aegithognathous. If the palate characters are sure indices of affinity, the two large groups of *Grallæ* and *Natatores* must be dismissed as unnatural, and their components rearranged in two other series, in each of which occurs a serial relation of families usually held to be widely separated, or, in some cases to represent nearly extremes of form. A cormorant or gannet comes next to the birds of prey, which only separate them from parrots. A goose is nearer to an eagle than to a gull. A pigeon comes nearer to a penguin or crane than to an insessorial bird. An albatross is more nearly related to a peacock than to a pelican. These, it is true, are among extreme instances; but the extremes as well as the means are a part of the system. In *Schizognathæ*, a sequence of groups is *Rallidæ*, *Laridæ* et aff., *Spheniscidæ*, *Rasores;* in *Desmognathæ*, a sequence is *Herodiones*, *Steganopodes*, *Raptores*. Discussion of these points is unneeded, as it would be merely a rehearsing of the principles that have hitherto guided all ornithologists in framing classifications. Here, characters of every sort are made subservient to one. The arrangement has the appearance—be it real or simulated—of a cryptogram, to which an arbitrary standard is the only key.

But ex parte statements do not do the subject justice; views for as well as against the system should be presented. Prof. Huxley considers *Charadriomorphæ* as a central group of Schizognaths, leading outward by three "distinct series or gradations." In one of these, *Otididæ* lead from plovers to cranes, and such genera as *Psophia* and *Rhinochætus*, thence to rails. In another, *Hemipodius* is intermediate between plovers and *Gallinæ*; whence *Syrrhaptes* leads to pigeons. A third series begins with the gulls, leads through petrels to auks, and so to penguins; "the osteological resemblances between a plover, a gull," &c., "being so close that it is utterly out of the question to regard these birds as members of different orders," (p. 455.) Conceding these series and relationships to exist, without reservation, still another point is easily raised. Passing from plovers to cranes and rails, in the manner indicated, the general affinities of some of the latter lead quite as naturally to certain Desmognaths, as herons and Totipalmates. I may instance *Heliornithidæ*, really ralloid, as Brandt has shown, if osteology goes for any criterion, but related to Steganopods, at *Plotus*. From plovers again, a pure grallatorial form, *Recurvirostra*, shows transition at least as sure as others claimed, to other palmate *Grallæ* as *Phœnicopterus*, and so to *Lamellirostres*, of *Desmognathæ*. In another series certain *Procellariidæ* lead into desmognathous groups. *Prion* has a lamellated bill, like that of a duck. *Halodroma* has a gular pouch like the Steganopods ; these last are directly affined to the herons by *Balæniceps* and *Cancroma*. In many general features an albatross is like a pelican. Another Cecomorph, *Colymbus*, is really totipalmate, like all Dysporomorphs ; the hallux being lateral and connected with the base of the second digit ; were its hind toe as long as a cormorant's and the webbing increased *pari passu*, it would be steganopodous. The relationships of the longest-winged Dysporomorph, *Tachypetes*, with the similarly constituted gulls and petrels, will scarcely be denied. In an opposite direction, the relations of some short-winged Cecomorphs, as auks and grebes, with similarly modified Dysporomorphs, as cormorants and darters, will hardly be overlooked. Not to multiply examples of these transitions, in another direction than that according with the requirements of the system, it does not appear that the links by which Schizognaths and Desmognaths are bound to each other are weaker than those by which either of the two is held together ; or so weak as those connecting, for example, *Raptores* with Steganopods. And however the present argument may be invalidated by insufficient or injudicious advocacy, the above given broad facts of comparative degrees of relationship remain.

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* I hold *Tinamus* et aff. to be the expression of the gallinaceous process towards, or tendency to inosculate with, *Ratitæ; i. e.*, a struthious phase of development or modification of a strictly rasorial idea.

† I am indebted throughout to Prof. Huxley's paper for statements of facts respecting palatal characters.

Since palatal modifications do not indicate groups of the taxonomic grade we have been considering, it remains to enquire how far they avail in the construction of lower associations. No one will question how nearly Prof. Huxley's subdivisions agree with natural families, or orders, as the case may be. *Charadriomorphæ* correspond very nearly with that eminently natural assemblage of smaller *Grallæ*, called *Limicolæ* or *Scolopaces*. *Geranomorphæ* are as nearly *Paludicolæ* or *Fulices*: with the addition of *Grus*, &c., which is here much more naturally assigned them among the herons. *Cecomorphæ* comprehend both macropterous and brachypterous swimmers ; but though the association may seem at first sight to be a little forced, really it is not so. *Longipennes* and *Urinatores* come next each other in any system, and some forms actually inosculate: e. g. *Halodroma* with *Mergulus*, *Puffinus* with *Colymbidæ*, (tibial apophysis, &c.) *Spheniscomorphæ* are penguins alone—order *Ptilopteri* Bp., tribe *Nullipennes* s. *Impennes* alior., *Spheniscidæ* auct.: touching Cecomorphs at the point *Alca impennis*. *Alectoromorphæ* are *Gallinæ*, excl. *Tinamus ;* and it is interesting, moreover, that the palate bones allow separation of *Peristeromorphæ*. The unnatural nature of too intimate association of pigeons with the true scratchers is borne out by appeals to every character, it would seem. *Chenomorphæ* are precisely lamellirostral or anatiform Natatores, a group respecting the boundaries of which there is no dispute. The Flamingoes, as might have been anticipated, are found to require Janus-like division—*Amphimorphæ*. *Pelargomorphæ* are precisely *Herodiones : Dysporomorphæ* are exactly *Steganopodes*. And so on.

Prof. Huxley has laid ornithologists under twofold obligations : First, he has pointed out in elaborate detail a certain character, the value of which was not only unknown, but also unsuspected before ; and has shown how perfectly it marks groups of a certain grade. Secondly, he has demonstrated once more—and, it is to be hoped, for the last time—the futility of attempting to found such fundamental divisions upon any one single character.

What has gone before is possibly an estimate of the value and office of palatal structure not very different from what the general verdict of ornithologists will be. That the palate bones afford nearly always correct indications up to a certain point may be regarded as demonstrated by Prof. Huxley's researches. That they may be taken as the basis of the primary division of *Carinatæ* will probably never be generally admitted. In ambiguous cases appeal to them may turn a nicely-balanced scale, and prove invaluable in limiting certain groups. But final appeal must not be made from all other characters to these; but from these—as one of many sets—as collateral testimony—to the total of the rest. As the sole basis for a system of ornithological classification, the scheme will probably remain in critical abeyance only until the time when its brilliancy shall have been forgotten, and its unsoundness alone be remembered.*

Professor Lilljeborg's system† begins with the same three primary divisions that Nitzsch adopted after abandoning *Ratitæ*, and reducing them to an order of *Cursores*. Further, however, it differs materially and is in some respects unique. It is particularly to be observed of this system, that no single set of characters—no special theory—guided its formation. The author takes a general average of characters, and seeks to harmonize, as far as possible, conflicting views of such ornithologists as have been led to propose schemes based upon special investigations. Bonaparte's ideas respecting *Altrices* and *Præcoces;* Nitzsch's researches on the Carotids and Pterylosis; Sundevall's results regarding wing-coverts and flexor muscles of the feet; Cabanis' studies on the scutellation of the tarsus and other points; Muller's generalizations respecting the lower larynx; not to mention other data, have all been brought into use, judiciously estimated, and carefully coördinated. It is certainly the most 'catholic' system that has ever been proposed; there are intrinsic reasons why we might anticipate its high excellence.

Having already given some reasons for my belief that all carinate birds at least may be primarily divided into three groups, I need not repeat them, in assenting unreservedly to the way in which Professor Lilljeborg draws the lines dividing Natatores, Cursores and Insessores. There are a few ambiguous forms: *Phœnicopteridæ* and *Heliornithidœ* are among them, coming between the first and second; some of the more terrestrial pigeons, or gallinaceous birds with barely elevated hind toe, may be others, coming between the second and the last. These may be noticed as well here as anywhere.

The Flamingoes are purely "grallatorial" in general conformation, but they are palmate, with duck-bill; and their internal structure is said to resemble that of *Anseres* more than Herons. Too much stress must not be laid upon the webbed feet, for some undoubted *Grallae* are palmate, and all *Natatores* are not. The carotids show nothing, for they are exceptional in the class of birds. The balance is very even; there is perhaps no more purely transitional type. The palate bones would carry them near *Chenomorphæ;* the birds are said, also, to be præcocial, another indication to the same effect. But as the author takes the condition of the thigh and crus with reference to the body as a primary feature, he consequently assigns *Phœnicopterus* to *Cursores*. *Heliornithidœ* are, has been said, pretty conclusively fulicarious; the author does not specially refer to them. Pigeons, usually placed in *Rasores* as a suborder, are here made an order of *Insessores*. They are palpable intermediate connecting forms; some terrestrial ones inosculating with *Rasores*, others, truly arboreal, as evidently coming under *Insessores;* a few are analogized if not actually affined with *Accipitres*. Now it is characteristic of *Cursores* to walk on the ground;

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*I should remark that these paragraphs were written before I had seen any of the many criticisms that Prof. Huxley's article has called forth. I am more gratified than surprised to find how nearly the views of some authors for whom I entertain high respect agree with my own. I make no change whatever in consequence of what I have lately read; for though I might now be inclined to add considerably to the above, the appearance of the very articles in question has rendered unnecessary what more I should have to say.

A correspondent, whose name, were I authorized to use it in this connection, would be recognized as that of an eminent ornithologist, writes just now:—"Inasmuch as [this system] is based upon a single set of characters, it cannot be otherwise than arbitrary, and hence unsatisfactory. So far as the anatomical facts presented are concerned, it has some value; but the arrangement I deem to be on the whole far from a natural one. In short, I cannot regard it as other than a retrograde step, notwithstanding the excellent character of the author as a naturalist. It is, it seems to me, far inferior to others of a much earlier date."

† English reprint of original Swedish: P. Z. S., Jan. 1866.

of *Insessores* to hop. Pigeons are cursorial in that they (invariably I believe) walk: and other rasorial features need not be dwelt upon. They are also schizognathous, like *Rasores*. On the other hand, it is a fundamental characteristic of *Cursores* to have the hallux elevated, though *Herodiones* are a single exception. This feature is not presented by the pigeons, which are moreover mostly as truly arboricole as the majority of *Insessores*. They are mostly *Altrices*, like the last. The balance appears in favor of their being *Insessores*, as the author holds them.

The Ostriches and affines are in this arrangement reduced to an order *Brevipennes* of *Cursores*. *Archæopteryx* is not noticed, as may be said of other extinct forms.

Twelve orders succeed to the three sub-classes; agreeing in the main with divisions almost universally recognized, and defined in an unusually satisfactory manner. A notable point of difference between this and other systems lies in the tenth order, *Strisores*, which, as framed, does not largely accord with any previously established group. It is "a polymorphic group." as the author says, not easy to define by positive characters An order *Zygodactyli*, equivalent to *Scansores* auct. is retained; here, if anywhere, ulterior revision and decided modifications may be required. The zygodactyle birds appear to have so long had their place as a distinct order more because it has not been clear what to do with them if dismembered, than anything else. Toes in pairs is a thoroughly artificial character, as used; it is universally allowed that it unites birds otherwise widely dissimilar. It seems to be really only a modification to which any one family or genus of several groups is liable; if so its value has been largely overrated. It is most probable that the "order" *Scansores* or *Zygodactyli* will be broken up, in time, or at least restricted to some one of the types—perhaps the parrots,—now included under it; more fitting places being found for the cuckoos, trogans, toucans, woodpeckers, &c.

Regarding Prof. Lilljeborg's *Natatores*, I may express my conviction that the four orders he defines are the only natural ones, and that as such they must ultimately prevail. I only criticise the division of these four orders into two "groups;" an intercalation between the subclass and the orders that is at least superfluous. Not that all the distinctions implied in the terms "*Simplicirostres*" and "*Lamellirostres*" do not obtain; but that the groups are inequivalent. *Lamellirostres* are not more different from the *Simplicirostres* than the several components of the latter are from each other. A goose, *e. g.*, is not more different from a gannet than a penguin is. On this ground I hold the division to be unnatural as well as unnecessary. The two groups are further redundant, in that they have no analogues in other parts of Prof. Lilljeborg's admirable system.*

With the foregoing qualifications I follow this arrangement very closely. But I think that ornithologists will find it necessary to adopt many more families and sub-families than this author does, particularly among higher groups. I find it so even among Natatores, as will appear in the sequel.

NATATORES.

Relations and analogies of the sub-class.

Swiming-birds are so definitely circumscribed, that there appear to be but two types holding disputable place. *Phœnicopteridæ* have just been noticed. *Heliornithidæ* have been located with the Grebes, by Schlegel and others, apparently on account of the lobed feet. But this is surely an error; the relationship is of analogy, not affinity. They have been referred to *Steganopodes*, next to *Plotidæ*, by Bonaparte and others; upon what ground does not appear. As already said, osteology carries them to fulicarious *Grallæ*. It would be interesting to know whether they are altrices or præcoces, and how far the palate agrees with that of *Geranomorphæ.*

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* I doubt, too, that the definitions of these groups will stand test without qualification. In general, as claimed, one is altricial, the other præcocial; but among *Pygopodes* are instances of both. Lamellation of the bill is a very general distinction; but *Prion*, among "Simplicirostres" has laminæ.

The "naturalness" of the division as a sub-class is sustained in a satisfactory if not conclusive manner, by the large number of types that *Natatores* include under natatorial modification; the open passages that lead from it to the other groups; the number of points where other groups infringe upon it; and especially the highly instructive way in which its four primary subdivisions repeat each other. I shall endeavor to point out the principal of each of these.

The passage from anserine swimmers to heron-like waders is so obviously through and by *Phœnicopterus*, that the point need not be dwelt upon.

The passage from totipalmate swimmers to the same waders is unquestionably through the *Pelecanidæ* and *Cancromidæ.* The affinities of *Balæniceps* and *Cancroma* among herons, with pelicans, have long been recognized and universally allowed.

The passage from urinatorial swimmers to certain of the *Grallæ* takes place from the point *Podicipidæ*, through *Heliornithidæ*, to fulicarious or paludicole waders, and from the same point through *Phalaropodidæ* to scolopacine or limicole waders. In each of these cases we have almost the only—if there be indeed any other—examples of the lobiped structure—a comparatively rare modification of the swimming foot. The phalaropes, besides being excellent swimmers, are further exceptional in their own sub-class in the texture of the plumage, which is completely duck-like.

The passage from longipennine swimmers to *Grallæ*, if not so evident, is nevertheless clear, in the osteological and pterylographic characters that are respectively more or less common to a gull, e. g., and the plover or snipe-like waders, as Nitzsch and Huxley have pointed out. Certain small petrels again, as *Oceanitis*, *Fregetta* and *Pelagodroma*, are exceptionally "grallatorial" in length of leg.

The waders coming next to swimmers, it is not to be expected that higher, *i. e.* rasorial, *Cursores*, still less a further removed sub-class, *Insessores*, should afford direct transitions; but as I shall endeavor to show, the swimmers give analogues to the main types of each of these sub-classes. Foreshadowing of the mammals in birds does not occur within the range of *Natatores*, unless the duck-like bill of *Ornithorhynchus* is a case in point. It really takes place at the point *Ratitæ*. It is among *Natatores*, as the lowest birds, that the counterfeit of another vertebrate type is found. The mocking analogy with fish is complete in the penguins.

The raptorial modification of *Natatores* is seen in the sub-family *Lestridinæ* of *Laridæ*. The habitus of these is that of land birds of prey—a universally recognized resemblance. In their food the Jaëgers are vulturine. Physiological analogy is borne out by physical characters. Jaëgers are the only cered swimmers, as Accipitres are the principal cered perchers. The claws of *Lestridinæ* are more "raptorial" than those of any other swimmers. A singular rugosity of the tarsi is shared by the Jaëgers and the most aquatic genus of *Accipitres—Pandion.*

The rasorial modification occurs in urinatorial swimmers. All these have short, more or less concave, wings that are rapidly vibrated, and fly with great impetus; very gallinaceous features. Some *Alcidæ* employ the characteristic habit of *Gallinæ* in constructing their nests; rasorial has developed into fossorial. Other auks, notably Phalaridines, instantly recall quails by their general aspect; a species has been named from the circumstance. The bill of *Mergulus* repeats a partridge's. Absence of the hallux that marks all *Alcidæ*, though sufficiently frequent in scolopaceous *Cursores*, is rare among the alectoromorph *Cursores*; yet it characterizes a family—*Turnicidæ.* One of the rarest modifications, viz., abortion of rectrices, that marks a family of *Urinatores*, is only again found in some representatives of a rasorial family—*Crypturidæ.*

Tubular nostrils are not a very common feature. It is the prime characteristic of the longest-winged and best flying family (*Procellariidæ*) of swimmers. Among higher birds it again occurs in certain *Strisores*, especially *Caprimulgidæ*, as well seen in *Siphonorhis*. It is interesting to observe that these birds, like the petrels, are among the longest winged and best flying of their own sub-class. And further, that they mock the swimmers in the elevation and sometimes lateral position of the hind toe, together with the presence of a membrane between the toes not to be distinguished from a true "web," and equal in amount to that of many "semipalmate" waders. This is entirely different from the actual cohesion of the toes that obtains in many *Insessores*. The obliquity of the hind toe, too, is the necessary antecedent feature to its union by webbing with the second toe, as in all steganopods. Pectination of the middle toe is another feature of these long winged *Strisores*, repeated in the longest winged swimmer—*Tachypetes*. Finally, the characteristic gular pouch of all totipalmates is represented virtually, if not actually, in the broad-mouthed, loose-throated Goatsuckers, &c.

The scansorial type is exemplified in certain swimmers. One of its essential features is such construction of the tail as will allow of this being used as an additional means of support, as best illustrated in the woodpeckers. It is repeated in the cormorants; birds with long, strong, stiff tail feathers, that use the tail as a third base of support when standing on level ground, and exactly as woodpeckers do, when clinging to rocky ledges. *Phalacrocoracidæ* are scansorial *Natatores*.

A certain family of higher "land"-birds is purely aquatic, deriving its whole subsistance from the water. I refer to the kingfishers. Their characteristic habit of sitting on projecting branches watching for their prey, and darting into the water to secure it, are repeated in the *Plotidæ*. In both families progression on land is almost denied.

The term "sea-swallow," universally applied in our own and other languages ("Hirondelle-de-mer," "Meerschwalbe,"&c.) to the *Sterninæ*, is expressive of a strong analogy, traceable both in general conditions and special characters. As to the former, I need only refer to mode of flight, and manner of hunting for prey, especially in such small delicate species as *Hydrochelidon fissipes*, e. g. The "skimming" of the swallow in the air, and its attitudes on the ground, are repeated in the tern. As to special physical points, I may instance shape of wing, and relative length of that member; length and furcation of the tail; and the remarkable shortness of the legs that in both groups renders walking difficult and unusual.

In the active pursuit of prey under water, the very highest Oscines are brought into analogical resemblance with the lowest swimmers, by the singular genus *Cinclus*.

I do not observe any special analogies of anatiform swimmers with higher birds; though some might possibly be traced. This strictly monomorphic family seems specially reserved as the means of perfect transit from swimmers to waders through *Phœnicopterus*.

Characters of the sub-class.

No one character can define *Natatores*. Covering of the knee by the skin of the body is the most general one, and one probably not found outside the sub-class; but it varies down to a minimum, ceasing to be diagnostic in certain *Longipennes*. Web-footedness is not an infallible indication; some *Grallæ* are palmiped, some *Natatores* are not. But these two, with qualified reference to two others, furnish the desired definition. Thus *Natatores are palmiped with the knee internal; or, if external, the bill neither recurved nor abruptly decurved; or lobiped, with the tail rudimentary.**

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* It might be advanced here, that I am liable to the charge of doing what I have above criticized others for doing, *i. e.*, making a division upon a single feature. But there is a distinction between simple "definition" (*i. e.* limiting) of a group, and its "characterization" in full. The foregoing phrase is merely a convenient word-formula for the ready recognition of any Natatorial bird, which could only be "characterized" by reference to several other features.

This expression is absolutely diagnostic; it marks every swimmer, and excludes all other birds. Reference to the bill is necessary to exclude the web-footed *Grallæ*. Nothing can be predicated from the wing-coverts, which are similar in *Cursores* and *Natatores;* nor from the carotids, which are double in nearly all of both sub-classes, the *Podicipidæ* alone furnishing an exception in *Natatores*. So with most other single characters useful or indispensable in arranging higher groups. We must chiefly rely upon special *combinations* of common or general characters.

The statement that all *Natatores* possess the oil-gland, which has its circlet of feathers, has no known exceptions. The gland usually has two openings; frequently more among *Steganopodes* and *Procellariidæ*. Powder-down tracts have not been observed in any. The pterylosis of the sub-class adheres closely to a particular type, in the breadth of the tracts, that are "strong" and definite, and in narrowness of the spaces. The inferior tract, as a rule, has no free outer branch; the dorsal is not interrupted by a true gap. *Laridæ* furnish exceptions to both these statements, in their scolopacine pterylosis; *Diomedea*, *Colymbus* and *Podiceps* have the dorsal gap; *Uria*, *Alca*, and *Fratercula* have a half-free outer branch reaching to the knee-covert. There is also a trace of this in *Anatidæ*, increased in *Procellariidæ*. "In all these cases the ventral portion, which is often independent only from the extremity of the sternum, is usually not only very broad but dilated towards the sides in the middle of belly; a structure which occurs only in water birds, and has already been very distinctly recognized among the *Scolopacinæ*." (Nitzsch.) The contour feathers are placed in regularly parallel, oblique rows, not separated by a space along the median line of the body. Notwithstanding the denseness of the plumage the ptilosis is not so continuous, even in the penguins, as in some Insessorial groups. The spaces are all covered with down-feathers, perhaps double. The contour feathers are so situated that every contiguous four form a rhombus, made quincuncial by a down-feather in the centre. Other smaller down-feathers are frequently intercalated in the rows of contour feathers. The latter are furnished with an extensive series of comparatively large cutaneous muscles, of which each feather may have several. Each contour feather has its accompanying filoplumes, which may be as many as ten, as *e. g.* in the goose. The modified diversely colored feathers about the head of cormorants (and some auks?) are believed to be filoplumaceous. The feathers are frequently devoid of after shafts, which appear, in general, to be complementary to down-feathers.*

The wings of *Natatores* are remarkably diverse in size and shape; the modifications are scarcely or not diagnostic of either orders or families. Thus the wings of certain *Procellariidæ* are exactly those of some *Alcidæ*; those of some *Pygopodes* and *Lamellirostres* are alike. In this sub-class we find all gradations between the two possible extremes; albatrosses, e. g., are the best flyers of any, and have the most remiges (50); penguins have none, affording the only instance in the class of abortion of quills; though other birds share the deprivation of flight. *Tachypetes* again vies with *Diomedea*. The Natatorial average of remiges is about 30; the number may fall to 25, and frequently ranges up to 40. Notwithstanding this, the primaries are constant, 10; the first of these, as a rule, is longest, but there are many exceptions. Macropterous swimmers, as a rule, have flat, narrow, pointed wings; brachypterous, concave, broad rounded ones. *Tachypetes* and *Podiceps* best represent the two extremes. *Alca impennis* furnishes a singular wing; useless for flight, yet morphologically perfect. The greater wing coverts are always longer than half the secondary remiges. The tail varies as much as the wings, both in shape and character of rectrices. As a general rule, the tail is small and rounded, with many short, rather soft rectrices; this may be called its typical condition. Abortion of rectrices definitely characterizes one whole family—*Podicipidœ*; in all others rectrices occur. A small, definite number of rectrices may be observed to be in inverse ratio to the size of the tail as a whole. The number is ordinarily 12, in those forms with well-developed tail; as in all *Laridœ*, most *Procellariidæ*, most *Phalacrocoracidœ*, the genus *Plotus*. A few Petrels, as some of the little *Procellariœ* proper (*Thalassidroma* auct.) are said to have only 10; the statement requires confirmation; most of them, as *Cymochorea*, mihi, and *Oceanites* K. and B., have 12. Many larger Petrels, as *Fulmarus*, *Daption*, &c., have 14; *Ossifraga gigantea* has 16. Among Cormorants the number of rectrices seems to be scarcely generic; some species having 12, others 14. As a rule *Alcidœ* have definitely 12 rectrices. *A. impennis* is said to have 18. *Phaëthon* has 16. *Sulidœ* have 12 and 14. *Tachypetes* has 12. Other genera included in the *Spheniscidœ*, *Colymbidœ*, *Pelecanidœ* and *Anatidœ* have a number varying from 12 to 32, though rarely over 24, and in instances where the larger numbers are approached or reached the tail may have an odd number, as 21, 23.* Not taking into account the small, short, rounded tails above mentioned as "typical," the *Natatores* furnish great variations in shape of the tail as a whole. It may be long and deeply forked, with more or less filamentous rectrices, as in nearly all *Sterninæ*, some *Larinœ*, the *Rhynchopinœ*, and more particularly the *Tachypetidæ*. It is large and square in most *Larinœ;* of corresponding size, and more rounded, or even approaching a wedge-shape, in many *Procellariidæ*. It is moderate or rather large and cuneate, in one gull, *Rhodostethia rosea*, and one Petrel, *Halocyptena microsoma*. In certain terns (*Anous*) it is both forked and cuneate, *i. e.*, lateral feathers graduated, central pair shorter than the next. It is short and cuneate in some ducks, and in *Spheniscidæ*; certain of the latter, however, have much better developed tail, with fewer rectrices, than others. The tail is long, broad, and fan-shaped in *Plotidœ* and *Phalacrocoracidœ*, where, moreover, the rectrices are exceptionally stiff. Finally, a few swimmers have curiously modified central rectrices. Thus in *Harelda glacialis* these are long-exserted and filamentous; a condition exaggerated in most *Lestridinœ* and carried to an extreme in *Phaëthontidœ*.

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* This paragraph is compiled from Nitzsch's Pterylography, Ray Soc. Ed. pp. 139-141.

There are few other modifications of the feathery covering that require notice. Some swimmers are ornamented with singularly modified feathers, chiefly about the head. Many *Sphenisciдœ*, and most *Alcidæ*, especially phaleridine forms, have curiously colored and shaped crests. Nearly if not all *Podicipidæ* are instructed with conspicuous ruffs of long, loose feathers; when these are deficient, as in *Podilymbus*, stiff bristles occurr. The bars of stripes on the neck of *Colymbidæ* are of keel-shaped feathers. Cormorants have colored filoplumes about the head; other, perhaps similar, patches are found on the thighs. Some *Anatidæ*, as *Aix*, and most *Merginœ*, are conspicuously crested. *Pelecanidæ* are crested, and have similarly elongated feathers on other parts, as the breast. The scapular feathers of many *Fuliguliнœ* are peculiarly curved; one or two genera of this sub-family have velvety-piled plumage. The well-known general condition of the plumage of penguins has suggested the name "*Squamipennes*." In many families or genera, plumage extends on the bill in varying degree; it usually, but not always, reaches the ankle joint, but the tarsus is never feathered, except in one genus, *Tachypetes*, and there only partially. No part of the body proper is naked, with the remarkable exception of the gular pouch of *Steganopodes*, carried to a maximum in *Pelicanus*. Other dermal outgrowths than feathers are rare; but an example of horny development is seen in the spur-winged genus *Plectropterus*.

The highly interesting modifications that make the swimming foot what it is affect the whole limb from hip-joint downward. The legs as a rule are placed further back than in Insessorial and purely Cursorial forms. But there is great difference in this respect among Natatores, and a regular gradation

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*I am again indebted to Nitzsch's incomparable work for part of the data for these generalizations regarding number of wing and tail feathers.

may be observed. In the highest forms, as *Anatidœ*, the feet are brought under the centre of equilibrium, and the body is consequently supported with its long axis horizontal. Some Steganopods—the next order—have much the same condition; in others, as Cormorants, the legs are much further back, and the body must be held almost upright. Most *Longipennes* are like *Anatidæ* in this respect, but here *Halodrominœ* offer almost the other extreme. In Pygopodous families the maximum of backward position of the legs and upright position of body is attained. A few or several *Alcidœ* stand and walk tolerably well, but all *Colymbidœ*, *Podicipidœ* and *Spheniscidæ* must rest nearly upright on the rump, and progress on land with extreme difficulty. Burial of the thighs and more or less of the crura in the skin of the body is ordinarily in direct ratio to backward position of the legs, and in inverse proportion to ease of walking. Nevertheless, some good walkers, as geese, have less free legs than certain small petrels that scarcely walk. As a rule, utility of the feet as pedestals and as paddles is directly complementary. The most adroit and untiring swimmers, and those that progress under as well as on the water with ease, are the poorest walkers. Compare a goose with a loon, *e. g.* In one order, Steganopods, we have the fact illustrated in contiguous families; pelicans do not follow their prey under water; cormorants do; there is a precisely corresponding angle of inclination of the body in each case. To avoid interference of the broad-webbed feet the legs are widely separated; a divarication begins in the axis of the femur, and is increased in other segments. Hence the characteristic "waddle" of ducks, &c.; their gait, compared with that of true walkers, corresponds somewhat to the difference that may be observed in the sexes of our own species, arising from difference in width of pelvis. There are many other interesting items in the construction of a perfect pair of paddles, too numerous to note here. A loon's legs may be taken as the type. Some time ago I worked out all the details, as seemed to me, in this case, and may be permitted to give the reference, in place of further observations.[*]

The tarsus most commonly presents no special noteworthy features. Occasionally it is extremely compressed, as among loons and grebes. Its horny covering has nothing of the importance that attaches to it among *Oscines*, for example, though the two primary types of reticulation and scutellation sometimes mark natural groups, as geese as distinguished from ducks. The tarsal envelope is fused in one genus.

The toes may be three or four; if the former, it is always the hallux that aborts. All have the normal number of phalanges, the relative lengths of which usually, if not always, conform to a general rule. In comparative length as wholes the hallux is always shortest; the others usually run 2d, 4th, 3d in length, but not rarely 2d, 3d, 4th. There is often only a very slight inequality in the 3d and 4th, exactly compensated by complementary difference in length of claw, so that the claw-tips fall together, *e. g.* many *Procellariidœ.* The hallux, as a rule, is present; its absence or rudimentary condition marks one whole family, *Alcidœ*, two sub-families, *Diomedeinœ* and *Halodrominœ*, of *Procellariidœ*, and one species of one genus (*Rissa tridactyla*[†]) of

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[*] Osteology, &c., of *Colymbus torquatus*, Mem. Bost. Soc. Nat. Hist., I, pt. ii, Nov., 1866, p. 131.

[†] In examining a great many *Rissæ* from the North Pacific, I have found a hitherto unnoticed and probably unsuspected state of things. There are in that region two perfectly distinct species of Kittiwake. One is *Rissa brachyrhyncha*, Gould, (=*R. brevirostris*, Brandt,) with coral-red or yellow legs, yellow bill, &c., &c. This has a very small hallux; but still one bearing a minute claw, that looks like a little black speck on the extremity of the knob. The other is the *R. kotzebui*, Bonaparte, or at any rate the bird I identified and described under that name some years since. Bonaparte's diagnosis is simply "*halluce magis explicato.*" Now this form is identical with and not distinguished from *R. tridactyla*, except in and by the hind toe. The hallux is almost always larger and better formed; and it ranges from a state scarcely or not different from that of *R. tridactyla*, up to a *perfectly developed condition, claw and all.* In some specimens the hind toe and claw are as large, comparatively, as those of any *Larus* I ever saw! The distinctive feature of the genus *Rissa* has disappeared. What makes the North Pacific Kittiwakes vary thus, while the Atlantic birds are constant, as far as known?

Laridæ. In the other sub-families of *Procellariidæ* it is scarcely more than an immovable sessile claw. When present, its condition varies. Without exception, it is raised above the level of the anterior digits; but the elevation is slight in all *Totipalmi*, among which are found the most arboricole swimmers, just as in *Ardeidæ*, of *Cursores*, which are pretty good perchers. Its direction is ordinarily straight backward; to which the best exception is seen in its oblique inward position in all *Steganopodes*, where, likewise, this toe is much longer than elsewhere. In *Spheniscidæ* the hallux is very small, lateral and elevated. As to its connection with the other toes or the tarsus, we find several modifications. In the first place, we have the condition in *Procellariinæ* of sessile inmobility. Next a lengthening and freeing, as in *Laridæ* and *Anatinæ*. Then with slight increase, or none, in length, there may be a broad membranous lobe depending from it, *e. g.*, *Fuligulinæ*, *Podicipidæ*. This lobe, again, may unite it at base with the tarsus or inner toe, as in *Colymbidæ*; a condition intermediate between the foregoing modification and the only other one to be noticed, viz., that characterizing the *Steganopodes*, when the very long hind toe completes, by webbing to the claws with the inner one, the totipalmate foot. In most or all those cases where the hallux aborts, I think its accessory metatarsal is still to be found beneath the skin of the tarso-metatarse. I have never sought for it in vain.*

Palmation is undoubtedly the prime characteristic of the swimming foot; yet it does not always obtain. Lobation marks one whole family (the Grebes.) But in *Podilymbus*, at least, there is a sort of compromise between the two styles; the toes being perfectly lobed, yet webbed at base. More or less imperfection of the webs in truly palmate forms exceptionally occurs. *Hydrochelidon fissipes*, e. g., has the webs so deeply incised that it is scarcely more palmate than such grallatorial genera as *Symphemia*, *Ereunetes*, &c. Some Anserine genera are defective in this respect. But ordinarily the free margin of the two or three webs departs but little (and that in concavity) from a straight line between the ends of the toes; it is sometimes a little convex.

The claws as a rule offer nothing of importance. They are small, short, stout, little curved, not very acute. One or two genera of *Alcidæ* have a claw on the second toe differing in all these respects from the others; it is ordinarily, also, laid flat, not upright. Rarely the middle claw is dilated and pectinated (*Tachypetes*) as in Herons, Goat-suckers, &c. The Grebes offer exceptional claws; these are broad, flat, and squarish in shape, much like human nails. *Rissa tridactyla* offers perhaps the only instance of a toe without a well formed claw.

The bill of *Natatores* is so variable in all its features that it is best considered under heads of the several orders and families. I may remark here that it appears under two principal forms: lamellate in all *Anatiformes* and one or two genera of Petrels; simple in all other swimmers; but in these its tomia may be serrate. In a great number of cases, it bears a nail at the end, of varying size, large or small, and in either case liable to be either very distinct or lost by fusion. This nail, it should be observed, is an affair of the horny covering altogether; not dependent upon the condition of the premaxillaries. The horny case is ordinarily continuous; but sometimes, as in Jaëgers and Petrels, it consists of many pieces.† In *Anatiformes* it is softer, more like ordinary skin than elsewhere, whence "*Dermorhynchi*" as a name of the family.

Anatidæ, *Laridæ*, *Procellariidæ* and *Podicipidæ* are cosmopolitan; but Petrels abound most and in greatest variety in Southern seas. Most *Steganopodes* are wide-spread, but *Tachypetidæ*. *Phaëthontidæ* and *Plotidæ* are chiefly tropical. *Colymbidæ* belong to the Northern Hemisphere. *Alcidæ* are Palæ-Ne-arctic, focussing in the North Pacific, replacing *Spheniscidæ*, which are exclusively

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* So, also, I find it in *Calidris arenaria*, a 3-toed sandpiper, in the *Ægialites*, &c.

† Cf. the writer's "Review of *Procellariidæ*," part v, Pr. A. N. S., Phila., May, 1865, p. 175.

Southern, and essentially Antarctic. Nearly all *Natatores* are either largely migratory, or else are widely wandering pelagic birds.

*Subdivisions of the Subclass.**

Assembled in such variety of character, swimmers may be easily and conveniently divided in several ways, according to the standard taken. But I presume only one of these can be the right (*i. e.* the natural) way ; and further, that *cœteris paribus*, the scheme that takes into consideration the greatest number of characters will come nearer the truth than one that proceeds upon isolated grounds. A *sine quâ non* of any scheme must be equivalency of value of the groups to which the same taxonomic rank is accorded.

There is no safe stepping-stone between the subclass and its orders. There are four orders, *i. e.*, four modes of expression of the Natatorial plan or idea. In the following definitions of these, diagnostic or more important characters are italicized :—

Ord. I. Pygopodes.—*Legs posterior*, *horizontal position of axis of body impossible ; most of crus* as well as femur buried. *Brachypterous ;* wings short, never reaching end of *very short*, *many-feathered tail*, that is sometimes *wanting.* Body depressed. Feet tetra- or tri-dactyle, *lobate or palmate*, *never totipalmate ;* hallux elevated, functional or not. *Bill not lamellate nor serrate ;* wholly corneous, entire. Nostrils lateral, mostly basal, *well formed*, *never tubular. No gular pouch. Tibia often with a long apophysis.* Carotids *single or* double. *Schizognathous.* Altrical or Præcocial. Scarcely ambulatorial; sometimes not flying at all ; *urinatorial ;* swim under as well as on the water ; lie deep on the water. Heavy, clumsy on land. *Natatorial Natatores.*

Ord. II. Longipennes —*Legs near centre of equilibrium, horizontal position of body usual.* Femur buried ; *crus largely* (or wholly ?) *free. Macropterous ; wings long, pointed, surpassing the base, and often the tip,* of the *large well formed few-feathered* tail. Feet tetra- or tri-dactyle ; *always palmate*, *never totipalmate ;* hallux, when present, free, elevated, very short, *functionless.* Bill *wholly corneous*, entire or *pieced*, unguiculate or not, *never laminate* (exc. *Prion*, &c.) *nor serrate.* Nostrils variously, *but always well-formed*, lateral or superior. *None*, or only a rudimentary gular pouch. Tibia *with or without* apophysis. Carotids double. *Schizognathous. Altrices.* The majority ambulatorial ; *all highly volucral ;* none urinatorial ; all rest shallow and swim easily on the water. Light, elegant in all three elements.† *Volucral Natatores.*

Ord. III. Steganopodes.—Position of legs variable ; *generally well posterior*, but sometimes approaching the preceding. Wings variable, but *generally long and pointed*, approaching or equaling the preceding. Tail variable, sometimes short and indefinitely feathered, usually long and few-feathered ; cuneate forked, rounded, or fan-shaped. Feet always tetra-dactyle, *totipalmate, hallux depressed, lateral, long, functional. Bill wholly corneous, never lamellate;* tomia *serrate* or not; its covering continuous or not, with or without a nail; *external nares very small or abortive. A gular pouch.* Tibia simple. Carotids double. *Desmognathous. Altrices.* Ambulatorial, or scarcely so; generally powerful flyers; *often good perchers;* urinatorial or not. Heavy, if not clumsy on land. *Insessorial Natatores.*

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* Reduce to an order, and *pari passu* reduce the value of subordinate groups, if *Saururæ*, *Ratitæ* and *Carinatæ* be accepted as sub-classes.

With such reduction in value, *Insessores*, *Cursores* and *Natatores* would become "orders" of *Carinatæ*, and the four "orders" indicated below would be suborders or "tribes,"—*i. e.*, simply collocations of families. Throughout this article I call *Natatores* a "sub-class" in a conventional sense only, as indicating one of the first divisions of a class *Aves*, as usually held.

Even with this depreciation in the scale, I do not suppose that the Avian groups have the value of those of the same name in other classes of vertebrates. Birds adhere so closely to a common type, that the extremes of difference in form found among them scarcely seem to indicate divisions of a higher grade than those marking orders in lower vertebrates ; in fact, it is a question whether *Aves* as a whole are more different from some other vertebrates than certain (*e. g.* reptilian) "orders" are from each other. But, however variously vertebrates may be primarily divided (as into *Hæmatotherma* and *Hæmatocrya*, into *Icthhyopsida*, *Sauropsida*, &c., &c.), the four "classes" of *Pisces*. *Reptilia*, *Aves* and *Mammalia* will probably always endure, and be virtually our taxonomically equivalent points of departure for further divisions. Therefore, as it seems to me, the rank of *Natatores* only hinges upon the question of *Carinatæ*, &c., as the primary divisions of *Aves.*

†To most of these characters *Halodroma* is a signal exception. But its tubular nostrils define its position.

Ord IV. LAMELLIROSTRES.—Legs, as in *Longipennes, near centre of equilibrium;* position of axis of body in walking horizontal. *Wings constant, moderate,* reaching to but not beyond, the *short rounded* (exceptionally long cuneate) many-feathered tail. Feet always tetradactyle, and palmate; *never totipalmate:* hallux elevated, moderate, free, simple or lobed, probably functional in all cases. *Bill lamellate,* but tomia not serrate, *covered with soft skin in greater part, with more or less distinct nail at tip.* Nostrils constant, well formed, latero-superior, subbasal or median. *No gular pouch.* Tibia simple. Two carotids. *Desmognathous. Præcoces. Highly ambulatorial*; good flyers; excellent swimmers; poor divers. Heavy, though not clumsy, in either element. *Cursorial Natatores.*

The sequence of these orders is fixed. *Pygopodes* are first or lowest; *Lamellirostres* last or highest, beyond question. It might seem, on several accounts, particularly position of legs, that *Steganopodes* should come next to *Pygopodes.* But we cannot put anything between *Longipennes* and *Pygopodes,* for they touch if not inosculate at the points *Halodroma* and *Mergulus.* Moreover, other *Procellariidæ* have the long tibial apophysis that characterizes divers, but disappears higher in the series.

Families and subfamilies of PYGOPODES.

The Penguins might be considered as presenting differences of more than family grade; they have been made a tribe or suborder (*Impennes, Nullipennes, Squamipennes, Ptilopteri,* auctt.) Thus they are unique in possessing no remiges, scaly feathers, not entirely connate metatarsals, flat pterygoids and arm-bones, and peculiar elbow-joint,[*] not to mention other lesser features. But their characters are mostly of degree, not of kind; and above all, the link between them and *Alcidæ* is so close and complete by *Alca impennis,* (extending even to elbow joint and metatarsals) that the differences are really not so great as appears at first sight.

Three other families are not open to question. The four are thus distinguished, by external characters alone:

Fam. SPHENISCIDÆ.—Feathers scaly. No remiges; wings useless for flight. Hallux minute, elevated, lateral, functionless. Feet palmate. Tail many feathered (with thirty or more rectrices, but sometimes fewer.) Usually with modified feathers on head. Bill various. Altrices.

I doubt there being two or more subfamilies; that is, I think we must pass directly to the genera (technically though one subfamily), all of which differ from each other by characters of about the same value. The genera are few —perhaps only two or three—based chiefly upon the bill and tail. These birds are specially related only to the next.

Fam. ALCIDÆ.[†]—Plumage normal. Remiges present, well developed (except in one instance.) No hind toe. Feet palmate. Tail small, but definitely few-feathered. Usually with modified feathers about head. Bill singularly various. Altricial and Præcocial?

Auks vary in details of form, particularly of the bill, with almost every species. The genera are numerous; all apparently safely grounded. It is rather difficult to group them satisfactorily into subfamilies; but there do seem to be three series of genera, the components of each of which are decidedly more intimately correlated with each other than with any of the genera of either of the other two series. We have therefore three subfamilies, as follows:—

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[*] But I do not believe that either of the two little bones at the elbow of these birds, as well as of Guillemots, represents a "detached oleocranon;" I hold them for true sesamoids.

[†] Cf. writer's monograph *Alcidæ,* Pr. A. N. S., Phila., 1868.

Subfam. *Alcinæ.*—Ptilosis reaching to or beyond linear nostrils; no crests; tail cuneate; bill sulcate, cultriform. Typical "Auks;" connecting with Penguins. Genera: *Alca*, *Utamania.*

Subfam. *Phaleridinæ.*—Ptilosis not reaching various nostrils; mostly crested; bill various, but always compressed, somewhat cultriform, often appendaged; tail squarish or rounded. A middle group, leading nowhere; sometimes under a quail-like mask. Genera: *Fratercula*, *Lunda*, *Ceratorhyncha*, *Sagmatorrhina*, *Simorhynchus*, *Ptychorhamphus;* the first named nearest *Utamania*, the last next to *Mergulus.*

Subfam. *Uriinæ.*—Ptilosis reaching to linear or rounded nostrils; bill conic or subcylindric, simple, usually much elongated; tail rounded or pointed; head not crested (exc. one species). "Guillemots." Genera: *Mergulus*, *Synthliborhamphus*, *Uria*, *Lomvia.* The last named repeating *Alcinæ* in coloration; grading towards *Colymbidæ* in the chars. of bill. The first (*Mergulus*) in quail-guise; and forming the inosculating point of the present order with *Longipennes* by means of *Halodroma.*

Fam. COLYMBIDÆ.—Plumage normal. Ptilosis reaching nostrils. Hallux well formed, semi-lateral, joined to base of inner toe. Wings pointed. Feet palmate; fourth digit lengthened. Tarsi flat, reticulate, their posterior edge smooth. No crests. Lores feathered. Tail short, but well formed. Bill constant, long-conico-compressed, simple. Nostrils linear, lobed. Claws narrow.

A small family, of (technically) one subfamily and only one genus, *Colymbus*, with some half-dozen species. Related to auks through *Lomvia.* Representing, by its quasi-totipalmate feet, the *Steganopods* among *Pygopodes!* But affinities really closest with the next family.

Fam. PODICIPIDÆ.—Plumage normal. Ptilosis not reaching nostrils; lores naked. Nostrils lanceolate, &c., not lobed. Wing rounded. Hallux well formed, lobed. Feet lobate, or lobate-semipalmate. Tarsi flat, their posterior edge serrate. Conspicuous crests, or modified feathers about head. Tail rudimentary. Bill simple, variable, stout or slender, conico-compressed, long or short Claws subquadrate, flat.

A family unique among water birds in its single carotid, lobed feet, abortive tail, and flat nails. Nearest *Colymbidæ* in affinity; replacing, in its subclass, fulicarious *Grallæ*,—in fact, linked therewith by *Heliornithidæ.* Counterfeiting some *Crypturidæ*, of gallinaceous birds. Its longest-billed and -necked genus representing in its own family the place of *Plotus* among Steganopods.

But one subfamily is usually recognized. There may be two, for one genus differs more from the rest than any of the latter do from each other. The following would be the diagnoses, but I scarcely think it necessary to make this distinction with such little difference:

Subfam. *Podilymbinæ.*—Bill stout, almost hooked. Nostrils sub-circular. Lores broadly naked. Frontal feathers bristly; no decided crests. Tarsus not three-fourths of the middle toe. Feet semipalmate, as well as lobed; hallux narrowly lobed. Genus: *Podilymbus.*

Subfam. *Podicipinæ*—Bill slender, straight at tip. Nostrils linear. Lores narrowly naked. Frontal feathers simple; usually conspicuous crests and ruffs. Tarsus three-fourths or more of the middle toe. Feet with only a small basal web in addition to the lobes; hallux broadly lobed. Genera:

Æchmophorus, *Podiceps*, *Sylbeocyclus;* possibly one or two others, but most of the genera invented or used by Kaup, Bonaparte, and others, are untenable, representing only specific characters. *Sylbeocyclus* (type *S. minor*) is the connecting link between the two subfamilies.

Families and subfamilies of LONGIPENNES.

There are but two families of macropterous swimmers, that moreover shade into each other so insensibly and completely that the condition of the nostrils is sometimes almost the only character. Thus *Thalassoica glacialoides* is a pure gull, even to colors, with tubular nostrils. In fact, I know of no positive unqualified character but this that will reach through the whole of the two families as a distinguishing mark. Still there are others of greater or less significance. Both the families are clearly differentiated into several subfamilies, which are much easier to define.

Fam. PROCELLARIIDÆ.—Nostrils tubular, lateral or superior, united or separate. Bill variable in shape, always hooked; its corneous envelope (always?) in several pieces ; rarely laminate. Wings long and pointed (one exc.) Tail variable in shape ; usually small, never very long, of 12—16 (rarely 10??) rectrices, of which the central are never suddenly long-exserted. Feet palmate ; hallux present, minute, functionless, or absent. Tarsal envelope sometimes continuous (a unique feature among swimmers !). Truly pelagic birds, independent of land. Altrices.

Three strongly marked subfamilies, thus:

Subfam. *Diomedeinæ.*—Nostrils lateral, disjoined, horizontal. Feet tridactyle. Wings extreme, in length of humerus and ulna, and with highest number of remiges (fifty) known among birds, but only ten primaries, as usual. Genera : *Diomedea*, *Phœbetria*, founded on sulcation of mandible and shape of tail.

The albatrosses, in size, contour, and length of wing, repeat the *Pelecanidæ* in their own family; in length of wing they are only otherwise approached by another Steganopod family,—*Tachypetidæ.* But still a constricted group, with no aberrant forms.

Subfam. *Procellariinæ.*—Nostrils superior, horizontal, united in one double-barrelled tube. Too various in other respects to be concisely characterized. Still, the central or typical aspect of the family ; throwing out feelers in several directions.

One group comprises the smallest species, with pointed wings, elastic flexible primaries, rather long tail, variable in shape ; the most slender and longest legs of the family. These birds are pelagic *Cypselidæ !* Genera: *Oceanodroma*, *Cymochorea* (= *Thalassidroma* Bp. nec. Vig.), *Halocyptena* (caudâ cuneatâ), *Procellaria* (ex Linn. = *Thalassidroma* Vig. auctt.), *Oceanites* (podothecâ continuâ), *Fregetta*, *Pelagodroma.*

Another comprises heavier birds, of medium size, with long hooked bills, long, strong, pointed wings, and short rounded (rarely pointed) tail. It seems to occupy the very centre of the family. But it has a strong pygopodous feature in the tibial apophysis of at least some of its members, thus pointing to the Loons and Grebes. These are "Shearwater" Petrels. Genera: *Majaqueus*, *Priofinus* (= Adamastor Bp.), approaching Fulmar Petrels, and *Puffinus* (including *Nectris*), from which *Thiellus* only differs in a longer, more pointed tail.

A third group consists of the gull-like Petrels, called "Fulmars." These are among the largest of the family ; stout, thick-set; tail of 14—16 rectrices, well-formed ; wings moderate, for this family ; bill stout, moderately hooked. A group scarcely worth retaining as distinct from the last, for of its three genera, *Fulmarus* and *Thalassoica* are almost side by side with *Priofinus ;* and the other, *Ossifraga*, with *Majaqueus. Ossifraga* points to the albatrosses, *Thalassoica* to the gulls ; the last hardly differs from *Fulmarus.*

A fourth group is represented by three genera, *Æstrelata*, *Pagodroma* and *Daption*, each distinctly characterized. The two last are unispecific. In the first I throw the very many species agreeing in medium size, strong largely-hooked bill, long wedge-shaped tail, and rather short wings. Its species have received a dozen, more or less, generic names. There are about a score of them. *Daption* is peculiar in its wide bill, with rudimentary lamellæ and quasi-gular pouch, indicating Anseres and Steganopods. *Pagodroma* is among petrels much what *Gygis* is among terns, and *Pagophila* among gulls.

The last group, called *Prioneæ*, is remarkably distinguished by the lamination of the bill, equal, in one genus, to that of *Lamellirostres*, and only here found outside that order. There is also a shape of bill in *Prion* corresponding to *Cancroma* among Herons! and the throat is somewhat pouched. One square-tailed, light-colored form *Halobœna* recalls the Gulls. Genera: *Halobæna*, *Pseudoprion Prion.*

Subfam. *Halodrominæ.*—Nostrils superior, vertical, united, on the culmen at base. Mandibular space wide, with a distensible skin. Feet tridactyle. Wings and tail, and general form, of *Alcidæ!* Genus: *Pelecanoides* (Lacép., about 1800; = *Halodroma*, Ill. 1811, et auctt)

A singularly aberrant form, only Procellaridian in the nostrils; standing at a point where *Longipennes*, *Steganopodes* and *Pygopodes* meet; Steganopodous in its dilatable throat, &c.; Pygopodous in feet, wings and tail. It is almost a *Mergulus.*

Fam. Laridæ.—Bill generally with continuous covering. Nostrils always lateral, linear, or lance-linear. Wings always long and pointed, reaching far beyond base of tail. Tail always well developed, definitely few-feathered (12 rect.), but of varying shape. Feet always tetradactyle; hallux small, simple, elevated, apparently never functional. Strong dashing flyers, good light swimmers, poor divers. Altrices.

A definitely circumscribed group, without any remarkably aberrant forms. Sharply divided by characters of bill, &c., into four subfamilies, thus :—

Subfam. *Lestridinæ* —Covering of bill not continuous; upper mandible instructed with a distinct cere; bill epignathous.* Tail squarish, but median rectrices abruptly long-exserted. Head never crested. Tarsi rugose; feet ambulatorial. Genera: *Buphagus*,† *Stercorarius*.†

Comprehending the "Jaëgers," or "Skua Gulls." Affording the only instances in the subclass of a cered bill. In this partition of the rostral envelope we have an interesting approach to an essential character of the preceding family,—an affinity borne out by the pterylosis. For, says Nitzsch, in the *Procellariidæ* "the tract formation of *Lestris* is elevated into the type of a group." The peculiar construction of the tail is only elsewhere met with among water birds in the Anserine genus *Harelda* and the Steganopodous one *Phaëthon*. The Jaëgers are marine Accipitres!

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* There are only four possible conditions of the bill, with reference to the relation of the tips of the mandibles to each other. (1) the upper mandible overreaches the under, and is deflected over it; (2) the under mandible extends beyond the upper; (3) the two meet at a point; (4) the points of the mandibles cross each other. I propose to call these conditions *epignathous*, *hypognathous*, *paragnathous* and *metagnathous* respectively. The first is exemplified by all the *Raptores*, *Psittaci*, *Procellariidæ*, &c., &c. The second is exemplified by the *Rhynchopinæ*. The majority of birds, especially *Passeres*, exhibit the third. Of the fourth I only know one instance,—the Cross-bills (*Curvirostra* Scop. = *Loxia* auctt.) The family *Laridæ* is the only one that comprehends examples of three of these forms; and here they are, as we have seen, almost diagnostic of the subfamilies.

In respect of the epignathous type, it should be noted that to constitute this form the modification should affect the premaxillary itself, and be perceptible in the skeleton; mere deflection of a point or margin of the corneous envelope of the bill is not sufficient; *e. g.*, *Empidonaces* are paragnathous.

That singular bird, the *Anarhynchus*, might be thought to represent a fifth kind; but I should judge it to be paragnathous. The modification in this case is of a different kind altogether; a species of bilateral asymmetry, like the bent vomer of certain cetaceans.

†If Mœhring's and Brisson's genera cannot obtain, we must take *Cutharacta*, Brünn., type *C. skua*, Brünn., and *Lestris*, Ill., type *L. parasitica*, Linn.

Subfam. *Larinæ.*—Covering of bill continuous: bill epignathous. Tail usually squarish; rarely forked or wedged. Head never crested. Hallux in one species imperfect. Tarsi almost always smooth. Feet ambulatorial. Genera: *Larus* (possibly with a few divisions), *Rissa*, *Pagophila*, *Chrœcocephalus*, *Rhodostethia*, *Xema*, *Creagrus.*

The central group of the family: all the genera closely related. Distinct, on the one hand, from *Lestridinæ*, but on the other shading into *Sterninæ*, through the smaller, hooded, forked-tailed. &c., species, the bill of which insensibly passes into the tern-like form. Altogether too many genera have been invented, not discovered, in the genus *Larus*. I would unite under this name all the large square-tailed, unhooded forms, of whatever color, doing away with *Blasipus*, *Adelarus*, &c, not to mention a number of worthless "*coups*," as M. Temminck would justly call them. *Rissa* is different in its feet, at least in the type of the genus. *Pagophila* is well marked in several respects; it corresponds to *Gygis* among Terns, and *Pagodroma* among Petrels. *Chrœcocephalus* may well embrace all the smaller square-tailed "hooded" Gulls; these go into the tern-like shape of bill. The other genera above named are based mainly upon shape of tail.

Subfam. *Sterninæ.*—Covering of bill continuous. Bill paragnathous. Wings extremely long and pointed. Tail generally long; commonly forked, but of other shapes. Hallux constant. Tarsi smoothish; feet small, scarcely ambulatorial. Head often crested; sometimes singularly so. Genera: *Gelochelidon*, *Thalasseus*, *Phœtusa*, *Sterna*, *Hydrochelidon*, *Haliplana*, *Anous*, *Inca*, *Gygis.*

Adhering well to a recognizable type, but varying in details of form, whence the numerous genera. *Gelochelidon* is gull-like, especially in bill. *Thalasseus* comprises the largest robust species, with a soft, flowing occipital crest. *Phœtusa* has large southern species with great turgid bill. *Sterna* is central, with many deeply-forked tailed species like *hirundo*, &c. *Hydrochelidon* is singularly fissiped, from defect of webs. *Haliplana* is nearly *Sterna*, but with different bill, feet and coloration. *Anous* is a singular form, with a long forked-graduated tail; *i. e.*, central feathers shorter than next, others again graduated. *Inca* comes near it, but has unique, curly plumes on the side of the head, as in the Cormorants, and especially some Auks! *Gygis* is the Tern expression of the idea of the Gull *Pagophila* and the Petrel *Pagodroma.* The Terns are marine *Hirundinidæ !*

Subfam. *Rhynchopinæ.*—Bill cultrate, hypognathous; otherwise as in the preceding subfamily. Genus *Rhynchops.*

The single genus is a Tern in everything but the anomalous bill. The light cancellated internal structure of the turgid part of the upper mandible suggests that of *Rhamphastidæ.* The Skimmers feed as whales do.

Families of STEGANOPODES.

This order contains no less than six families, none of which have more than a single subfamily. Regard for equivalency of groups necessitates this view. For if we institute two families, upon whatever basis, as some have done, we shall find that their subfamilies are fully as different from each other as the families are. Recognition of six families here, and only one with numerous subfamilies among *Lamellirostres*, might not seem at first sight to be based upon parity of reasoning. But I think the distinction is one with a difference; and one too for which a good reason can be shown. *Steganopodes* are compounded from other *Natatores*, that is, forms have been taken from other orders, furnished with a pouch, webbed hallux and abortive nostrils, and otherwise modified to make up this order. Hence the dissimilar types, each representing a family. This is not so with *Anseres.* I cannot find the centre of *Steganopodes;* the families seem all peripheral, looking towards other groups. They show no tendency to merge into each other; they represent a scattering group. And in general among birds, the closer the inter relation of forms included in a group of any grade, the more definitely circumscribed is that group from its surroundings ; and conversely.

Fam. SULIDÆ.—Bill very short, serrate, decurved at tip, but not hooked with a distinct nail ; its covering continuous. Nostrils abortive. Gular sac undeveloped. Wings mediocre. Tail large, cuneate, definitely few (12—14)-feathered. Head not crested. Feet ambulatorial. Body with remarkable pneumaticity ; not much depressed. Taken from* Geese. Technically one sub-family. Genus : *Sula ;* perhaps another sufficiently distinct.

Evidently anserine in form and general appearance, as well as many details. The serrated simulates the lamellated bill. The wings are like a goose's ; the tail of few feathers repeats that of some *Anatidæ* ; the feet are strongly ambulatorial.

Fam. PELECANIDÆ.—Bill very long, slender, but strong; its covering not continuous ; not serrate ; distinctly hooked with a nail. Nostrils rudimentary. Gular sac at a maximum. Wings extremely long, with upwards of forty remiges. Tail short, rounded, indefinitely many-feathered. Head crested. Legs columnar, very stout. Body with unusual pneumaticity ; moderately depressed. Taken from Albatrosses. Technically one subfamlly. Genus : *Pelecanus ;* perhaps another.

The immense, many-feathered wings, and the size and general appearance of these birds, recall the Albatrosses. So does the hamulate, broken-covered, non-serrate bill. Progression in either of the three elements is similar ; neither of the birds can swim under water. The enormous pouch represents the extreme of development in the order. Yet some of the family to which Albatrosses belong have it; witness the genus *Pelecanoides.*

Fam. PHALACROCORACIDÆ.—Bill mediocre in length, rather slender, strongly hamulate, non-serrate, but its covering scarcely broken. Nostrils obliterated, at least in the adult state. Gular sac moderate. Wings short or medium. Tail large, fan-shaped, very stiff, definitely few (12—14) feathered. Head with curiously modified feathers. Legs far back, not ambulatorial ; upright position necessitated. Pneumaticity slight. Body greatly depressed. Heavy flyers; excellent divers. Taken from Auks. Technically one subfamily. Genus : *Phalacrocorax ;* but probably capable of well-founded divisions.

These are palpably pygopodous ; representing the extreme, in this respect, of the present order. They are forced to stand upright, and use the tail as additional support. They progress under water better than any other totipalmate birds, except the *Plotidæ.* The curious colored feathers about the head are those of Auks and Penguins. By remote analogy, there is a resemblance to *Scansores.*

Fam. PLOTIDÆ.—Bill very slender, straight, not hooked, sharply paragnathous, subserrate, its covering continuous.. Nostrils minute. Gular sac small. Wing short. Tail large, fan-shaped, 12-feathered. Legs far back; used on land chiefly in perching ; position more or less upright. Pneumaticity ordinary. Body depressed. Poor flyers; unsurpassed divers. Taken from Grebes. Technically one subfamily. Genus: *Plotus.*

The analogy, if not actual affinity, is very striking in this case. Physically, the long neck, style of bill, shape of wings and position of feet, are like the same parts in *Podicipidæ.* Physiologically the Darters share with the Grebes a habit almost confined to these two families: that of sinking back quietly in the water, leaving only the bill exposed. Both are unrivalled divers. Moreover, we have in that singular family, the *Heliornithidæ*, an actual link between Grebes and Darters; further carried to fulicarious forms.

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* Not actually, of course, but potentially, or ideally.

Fam. TACHYPETIDÆ.—Bill rather long, stout, strongly hooked, its covering not continuous. Nostrils very small. Gular sac highly developed.* Wings and tail excessively long and strong; the latter deeply forked, 12-feathered. Legs extraordinarily† short, well forward, but scarcely used. Tarsi plumose; middle claw pectinated. Unsurpassed flyers: scarcely swimmers; not divers. Taken from Petrels. Technically one subfamily. Genus: *Tachypetes.*

The tarsal ptilosis, and pectination of the middle claw, are unique in the subclass; the webs are more deeply incised than usual. In wings, tail and bill these birds are modified Petrels.

Fam. PHAETHONTIDÆ.—Bill medium, stout, straight, sub-serrate, paragnathous, its covering continuous. Nostrils small, but pervious. Gular sac smallest in the order; wholly feathered. Wings long and pointed. Tail moderate, but with long-exserted, filamentous median rectrices; 16-feathered. Feet well forward, short and stout; horizontal position of body necessitated. Excellent flyers; good swimmers; not divers. Taken from Terns. Technically one subfamily. Genus: *Phaëthon.*

The gular sac is scarcely more than rudimentary, and it is fully feathered; the nostrils are comparatively well developed. The bill is almost exactly that of a Tern. The filamentous tail feathers are rarely found outside *Sterninæ.*. The general resemblance to a Tern, in physical characters, as well as mode of life, is too obvious to require further comment.

So we see that each main group of water birds has been laid under contribution to form this scattering polymorphic family, a comprehensive mask for the rest.

Family and subfamilies of LAMELLIROSTRES.

A completely circumscribed group, of only one family, *Anatidæ*, whose characters are those of its order. The only break in the family is at the point of departure from *Natatores* to *Grallatores*, where the way is opened for the passage from *Anatidæ* by *Phœnicopterus.* There are six subfamilies, just as there are six families of the preceding order. These are mainly distinguished by the varying combination of characters common to several; but some introduce peculiar features. Of the latter, *Merginæ* are the furthest removed, perhaps, from all the rest. They have consequently been considered by some as a separate family. But a merganser is scarcely or not more different from a duck than a swan is. Regard for equivalency of groups therefore requires it to be placed as a subfamily of *Anatidæ.*

Fam. ANATIDÆ (chars. as above).

Subfam. *Cygninæ.*—Neck of extreme length for this family. Bill stout, high, and compressed at base, wide and depressed at tip, longer than head, sides parallel. Nail narrow. Lamellæ of upper mandible vertical, in one row. Soft skin of bill reaching towards, or to, eyes.‡ Wings ample: the inner remiges highly developed. Tail short, rounded, indefinitely many (20+)-feathered. Tarsus short, reticulate. Feet large; webs always full. Hallux small, elevated, with a small lobe. Trachea convolute, entering sternum (always?). Sexes similar. Species of largest size in the family, proverbially elegant swimmers, strong flyers, poor walkers; do not dive. Genera: *Cygnus*, *Olor*, *Coscoroba*, *Chenopsis.*

Subfam. *Anserinæ.*—Neck lengthened; shorter than in the foregoing, longer than in any of the following. Bill much as in foregoing, but generally not longer than head, sides converging, base very high, nail at end large, generally forming the whole tip. Lamellæ as before. Lores definitely feathered (always?). Wings mediocre, sometimes appendaged. Tail short, rounded, rather many (16+)-feathered. Tarsus reticulate; longer than middle toe (always? ?). Feet moderate, webs sometimes defective. Trachea simple, at least not entering sternum. Sexes usually similar. Of large and medium size; strong flyers, good swimmers, and especially good walkers; do not dive. Genera: *Anser*, *Bernicla*, *Chlœphaga*, *Cheniscus*, *Chenalopex*, *Plectropterus*, *Choristopus*, *Cereopsis*, *Sarkidiornis*, *Anseranas*, *Dendrocygna*; but some of these may be only subgenera, on synonyms.

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* The Frigate-birds have more of a pouch than they are usually given credit for. Mr. Cassin's figure, in Gillis' U. S. Naval Astron. Exp., is not exaggerated.

† The abbreviation of the tarsus in this case probably represents the extreme of this feature in the class *Aves.*

‡ The genus *Choristopus*, Eyton, apparently Anserine rather than Cygnine, is said to possess this character ("rostrum longum acuminatum cerâ ad oculos tendente."—Eyton, Mon. Anat.) If so, the character is not unexceptionable.

A rather large group; none are entirely swan like, but on the other hand some forms grade toward the ducks, and their position is open to discussion. Such especially is *Dendrocygna*, but its reticulate, not scutellate, tarsi, apparently define its position. *Plectropterus* is the only armed-winged swimmer. *Chlœphaga* and *Anseranas* have more or less defective webs. The body is not so depressed in the geese as in other subfamilies; the feet are perhaps further forward; the species stand high, and walk better than any other *Anatidæ*. Some are more or less arboricole, like many ducks.

Subfam. *Anatinæ*.—Averaging smaller than either of the preceding; neck usually much shorter. Bill broad and depressed towards tip; rarely or never so high at base as in *Anserinæ;* of various details of shape, but rarely if ever gibbous. Lamellæ vertical, in single row. Wings mediocre; the scapulars or tertials never curly. Tail short, usually rounded, sometimes longer, and pointed; of varying number of, but generally few, feathers; its coverts always ample. Feet moderate, rather further forward than in the succeeding; hallux simple. Body depressed. Head sometimes crested. Sexes dissimilar. Strong flyers, good swimmers, poor walkers, scarcely diving at all; many are arboricole. Genera: *Tadorna*, *Casarca*, *Leptotarsis*, *Anas et aff.*, *Spatula*, *Aix*, *Cairina*, and others.

The river ducks have been so extensively subdivided, that many of the distinctions commonly claimed as generic are not of more than specific value. Some of these genera, so-called, could not stand a moment did they not take color from the birds' colors. I think the number must be reduced, and that *Anas* can conveniently hold some half-dozen of them.

Subfam. *Fuligulinæ*.—With the characters in general of *Anatinæ*, but the feet placed further back and wider apart, apparently, and much larger, with broader webs; the tarsi short. Hallux with a large hanging lobe. Tail sometimes narrowly long-pointed, its coverts always normal. Scapulars or tertials often curly. Bill frequently gibbous. Strong flyers, very poor walkers, excellent swimmers, and the majority dive well; decidedly marine. Genera: *Fuligula et aff.*, *Oidemia et aff.*, *Somateria*, and others.

The sea ducks form a group usually distinguishable on sight from the preceding, and well characterized; yet it is difficult to find any positive feature applicable to all, except the large-lobed hallux; this is simple in the river ducks. But the feet are comparatively much larger. The species are mostly marine, diving well, and scarcely walking. As in the preceding group, the genera are altogether too many; but, likewise as in that case, I am not prepared to speak authoritatively as to the amount of reduction that would be desirable. Above, I only indicate principal series or sets of genera. Thus *Fuligula* has grouped about it *Fulix*, *Aythya*, *Nyroca*, *Clangula*, &c., just as *Anas* has *Nettion*, *Querquedula*, *Mareca*, *Dafila*, *Chaulelasmus*, &c. *Oidemia* might contain all the "Scoters," as *Pelionetta*, *Melanetta*, &c. Another central point has grouped about it forms like *Histrionicus*, *Polysticta*, *Camptolæmus*, *Harelda*, &c. *Somateria* will embrace all the "Eiders" with gibbous, partly feathered bill. This is merely an indication of the grade of differences that I would be inclined to consider generic.

Subfam. *Erismaturinæ.*—As in *Fuligulinæ*; but the rectrices rigid, lance-linear, acute, the coverts extremely short. Nail of bill chiefly inferior. Genera: *Erismatura* (et *Biziura* alior.); and *Thalassornis*?

A group of one, perhaps two, genera, and upwards of a dozen species, like ordinary sea-ducks, but differing in the curious condition of the tail, which corresponds to that of the Cormorants in their order.

Subfam. *Merginæ.*—Bill long, slenderer and narrower, more nearly cylindric in its continuity, than in either of the foregoing. The nail narrow, forming a true hook. Upper mandible with a double series of laminæ on each side, set obliquely backwards like saw-teeth, the single row in the under mandible fitting between them. Otherwise much as in *Fuligulinæ.* Mostly crested. Sexes dissimilar. General habitus as in the sea ducks. Genera: *Mergus*, *Merganetta*, *Lophodytes*, *Mergellus.*

A small group, well characterized by the bill. It offers the most conspicuously crested members of the family. The habits of the "fishing-ducks," as they are called, are much the same as those of the sea-ducks.

Characters of some new HEPATICÆ (mostly North American), together with Notes on a few imperfectly described Species.

BY COE F. AUSTIN.

Scapania Peckii, Aust.

S. minuta, compacte cæspitosa, valde surculosa; caule subsimplici serpentino-erecto vel adscendente 3—4 lin. longo sursum accrescenti laxe vel subimbricante foliato; foliis integerrimis obtuse complicatis bilobis, lobis subconformibus late ovatis plerumque obtusis apiculatisque, dorsali parce minori; surculis sursum subdecrescentibus dissite foliatis, foliis subdifformibus acute bilobis varie modo directis complicatisque suberectis vel plerumque e basi erecto patuli-recurvis nonnullis interdum explanatis; perianthio parvo subcuneato terminali et laterali sessili valde compresso, ore truncato integerrimo sæpe subrecurvo; foliis involucralibus conformibus nonnullo subdenticulatis; rete foliorum e cellulis minutis subrotundis hyalinis poriformibus, intersticiis latissimis fulgido-pellucidis confluentibus instructo.—*Hep. Bor. Amer. Exsic. ined.*, *No.* 20.

On old logs in woods, near Belleville, Canada West, John Macoun (1865). Adirondack Mountains, New York, Prof. C. H. Peck (1867); also about Jordansville, N. Y. (Austin, 1868).

Remarkable for its minute size (being about the size of *Jungermannia Helleriana*), obtusely complicate leaves with the upper lobe sometimes small and tooth-like, at other times nearly equalling the lower one; and for the great number of surculi, which are extremely variable in size, and clothed with smallish leaves, which resemble very much those of *Jungermannia Helleriana*, or *J. minuta*, and are very different from those of the main stems. The gemmæ bearing leaves occupy the middle of the stem, which is interrupted on account of them; they are usually ovate, subentire and subtruncate at the apex, and closely wrapped about the stem.

Resembles small forms of *S. exsecta* (Schmid), but is readily distinguished by its compressed perianth, never tridentate leaves, &c.

S. brevicaulis, Tayl., with which it may be possible to confound our species, is larger, with much more condensed stems and vertical leaves, and is destitute of surculi. Moreover, the perianth is very different, being scarcely more compressed than in *S. obtusifolia.*

Scapania Bolanderi, Aust. Mst. 1865.

S. caule subdichotomo-ramoso cæspitoso subadscendente; foliis acute complicatis grosse ciliato- vel subinciso-dentatis siccate non mutantibus, lobo